$$\tilde{x}^{(l)}(n)=\sum_{i=0}^{L-1} r^{(l)}(i)\square x((n-iM))_{P,N}\square R_N(n)\square\eta(n,i),\ n=0,1\ \dots\ N-1 \tag{24}$$

**[0053]** From formula (22), we can be seen that this method needs only once IDFRFT. After subcarrier modulation, the candidate signals of FRFT-OFDM can be weighted and obtained directly by the circular shift of the signal in the time domain, and the IDFRFT process does not need to be performed multiple times. Select the candidate signals $\tilde{x}^{(l)}$ with minimum PAPR in the time domain as transmission signals. The weighting factor $r(i)_{opt}$, which can make the PAPR of candidate signals minimum in the time domain is used as the sideband information, and is sent to the receiving end.

$$r(i)_{opt}=\underset{\{r^{(1)}(i),\dots,r^{(S)}\}}{\arg\min}\ PARP\ \{\tilde{x}^{(l)}(n)\} \tag{25}$$

**[0054]** Since the $b^{(l)}$ sequence has only L non-zero values, this method reduces the computation complexity of fractional circular convolution between x and $b^{(l)}$, that is, FRFT-OFDM signals x(n) in the time domain can be obtained by only one time N-point IDFRFT calcuation. The candidate signals can be obtained by making the x(n) periodic extension and the circular shift based on chirp, and the results can be further weighted. This method avoids the parallel computation of multiple N-point IDFRFT as required by the SLM and PTS methods. The system selects the signal with the minimum PAPR as sideband information which will be sent to the receiving end. FIG. **5** shows the principle of the method in the transmitter. At the receiving end, $r^{(l)}$ (i) can be transformed into $R^{(l)}$ (m) using discrete Fourier transform, and B can be obtained in accordance with the formula (13) and formula (14). Thus, the original transmitting signals can be recovered.

**[0055]** C. The Computational Complexity of the Method for PAPR Reduction in FRFR-OFDM Systems

**[0056]** In order to get time-domain FRFT-OFDM signal x(n) after subcarrier digital modulation, it needs an N-point IDFRFT calculation in this method. In the implementation of the project, there are a variety of DFRFT discrete algorithms. In this method, we use the Pei DFRFT algorithm to perform an N-point IDFRFT. This algorithm needs

$$\left(2N+\frac{N}{2}\log_2 N\right)$$

times complex multiplication operation. In order to obtain $x((n-iM))_{P,N}R_N$ (n), we need to turn left for a period of periodic extension of chirp and we need N-times complex multiplication at this time. It needn't repeat the calculation because $\phi$(n,i) are the same for each alternative. And the number of $\phi$(n,i) is L which can be obtained by (L−1)□N-times complex multiplication. According to the formula (18), candidate signals whose number is S can be obtained by making $\phi$(n,i) and $r^{(l)}$(i) weighted. At this time, each candidate signals can be obtained by NL-times complex multiplication. Therefore, the entire method needs a total number of complex multiplications as shown:

$$2N+\frac{N}{2}\log_2 N+N+(L-1)\square N+LNS=(2+L)N+\frac{N}{2}\log_2 N+LNS \tag{26}$$

**[0057]** In general, when the L is 4 or larger, there is a significant reduction of PAPR using this method. Because this method uses only one N-point IDFRFT operation and the value of L is not large, the present method has lower computational complexity than that of SLM and PTS methods. Table 1 is a summary to compare the number of complex multiplications of the SLM method, the PTS method, and the method of the present invention.

TABLE 1

the computational complexity of SLM, PTS, and the present method

| Method | Main calculation | Number of Complex multiplications |
|---|---|---|
| SLM | Take $M_1$ times IDFRFT with N-point, resulting in alternative signals whose number is $M_1$ | $K\square\left(2N+\frac{N}{2}\log_2 N\right)+NKM_2$ |
| PTS | Take IDFRFT with N-point and K-number, resulting in alternative signals whose number is $M_2$ | $M_1\square\left(2N+\frac{N}{2}\log_2 N\right)+M_1N$ |
| the present invention | Take once IDFRFT with N-point, resulting in alternative signals whose number is S | $(2+L)N+\frac{N}{2}\log_2 N+NLS$ |

## EXAMPLES

**[0058]** The following examples are provided by way of illustration only, and not by way of limitation.

**[0059]** FIG. **5** is a block diagram of the PAPR reduction method of the present invention. The steps of the PAPR reduction method are as follows.

**[0060]** (1) At a transmitting end of the FRFT-OFDM communication system, perform an N-point inverse discrete fractional Fourier transform (IDFRFT) of digitalized complex input data X of length N and converting it into the time domain to obtain FRFT-OFDM subcarrier signal x(n), wherein n is 1, 2 , . . . , N.

**[0061]** (2) Use a multiplexer to perform a p-order chirp periodic extension of the FRFT-OFDM subcarrier signal